energized, and its armature is raised, together with the armature of B^2, to which it is mechanically connected. This action, just as when B^2 was energized, results in stopping the busy wheel, starting the power mechanism and dropping shuttle 54 into the selective position. It further permits the power mechanism to complete the rotation begun under action of the starting magnet, B^2, and to return to its normal position, when it will auto-- tically stop, re-establishing the ground circuit at battery B' through wheel T.

In completing its rotation, the master shaft performs a number of operations which are about to be described. Two shuttles, 55 and 54, have now been dropped. These shuttles, as shown at C in our illustrations, are each provided with a toothed sector which when the shuttle is dropped, engages the pinion, E', at the front of the machine. The opposite ends of the shuttle are connected to the terminal carriages of the subscribers, which, as before stated, are brought into contact with two power bars, M', running at right angles to the bars, M. The power mechanism now permits E' to rotate, thus throwing the upper ends of the shuttles forward under the shuttle-rods, E, the carriages being drawn forward with them along the rods, M. Just above the selector mechanism, shown in the left-hand end view of the machine, a series of oscillating stops may be seen arranged in the arc of a circle. A lever, S', sweeps along this arc, engaging the first stop in its course and throwing it out of its normal sweep. This lever, which is connected by gearing to the pinion, E', is operated in a forward direction by a weight hung from this pinion, and is returned positively by a cam which operates levers V and S, the latter being keyed to the shaft on which lever S' is secured. If the machine had been idle before our signal 54 was sent in, the first stop would be engaged and thrown up and the rotation of pinion E', and the two shuttles engaged would be thereby limited. This act brings the two subscribers' carriages in line with the first pair of conducting rods, M^2, which in this machine take the place of the cord and plug of a manual system. Had the second stop been engaged, the carriages would have been brought into contact with the second pair of rods, M^2. It will be noticed that only ten talking positions are provided for on this machine. This percentage has been found ample in manual exchange practice, for practically never do all subscribers desire to talk at once.

The next act of the power mechanism is to lock the shuttles in position, which is done by lifting them upward until the hooks on their upper extremities engage the rods, E. Our front view shows several shuttles thus locked. In oscillating its stop pins, the lever S' closes the circuit of the battery S^2 through the first of a series of ringer controlling magnets, F'. This circuit contains a shuttle-carrier, C'. Had our subscriber 54 been busy, this carrier would have been dropped so that no signal could be sent. We assume, however, that line 54 is not busy, so the controller magnets will operate to release lever, F^2. By this time the first of a series of controller disks, G, will begin to rotate, bringing their contact strips into engagement with the set of brushes shown in the view at the left-hand end of the machine. The brushes, G' and G^2, connect the ringer, G^4, in multiple with the subscribers' circuits and send each subscriber a signal. The brush, G^3, short-circuits the battery, F^3, through part of the rotation of the disk and permits magnet, F, to be energized, which prevents the clearing-out mechanism from operating. The subscribers now take down their receivers and begin conversation. This act reduces the high resistance of the subscribers' circuit by shunting the ringer of, say, 1,000 ohms and providing a path through the transmitter and receiver of about 75 ohms. A sufficient current therefore flows through magnet, F, to powerfully energize the same. This continues until the subscribers are through talking and hang up their receivers, which act again increases the resistance of the circuit and reduces the flow through the magnet, F, to such an extent that it drops its armature and permits detent, F^4, to drop to its normal position in front of a continually-reciprocating carriage. There are ten clearing-out magnets, F, one for each of the oscillating stops operated by a lever, S'. The detents, F^4, when dropped to their normal positions engage those oscillating stops which have been thrown up by a lever, S', and restore them to their normal positions. The shuttle locks are thus released and return to their positions.

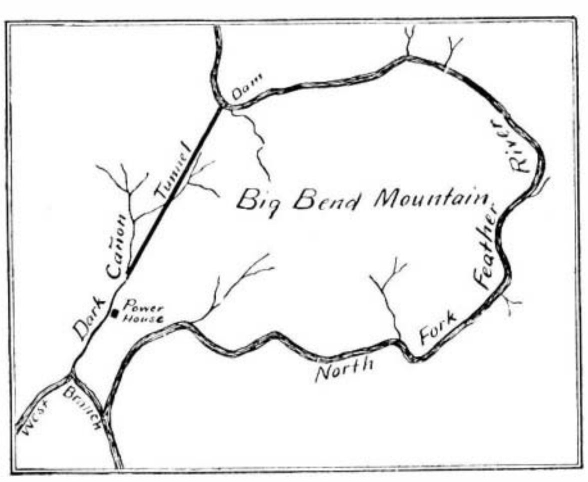
These operations, though seemingly numerous and complicated, are nevertheless automatically taken care of and consume but a few seconds of time. The instructions to the subscriber which are printed on the sender box are very simple, requiring merely the setting of the dials and the turning of the calling knob; it is not necessary to hold the receiver to the ear. In but a few seconds the subscriber's bell will ring and inform him that the connection is made. If the bell does not ring, he will know that the subscriber called is busy. Safety devices are provided in the sender which prevent an incomplete call from going in, and after the call is once set, the instrument is beyond the subscriber's control until the complete signal has been sent. Since the entire mechanism of the exchange is in the main mechanically operated, it requires but small battery power to energize the few magnets employed. A trouble test is provided, whereby any line which is out of order will immediately connect with the telephone of the wireman at the exchange. Any number of subscribers can be accommodated by this system, the requirements being simply an extra machine for every additional hundred subscribers. These machines are all joined to each other in such manner as to permit any two lines in the entire system to be connected together. The limited space at our disposal prevents us from enumerating the many advantages of this machine over the manual system, but these should be readily apparent to anyone acquainted with the tremendous complications of a large telephone exchange.

THE BIG BEND TUNNEL FOR POWER DEVELOPMENT.

BY FRANKLIN RIFFLE.

The recent incorporation of the Feather River Power Company recalls an ill-fated river-bed mining enterprise which for boldness of design, enormous outlay of capital, and barrenness of results, is certainly without a parallel in the annals of river-bed mining in the State of California.

In 1882 the Big Bend Tunnel and Mining Company was organized for the purpose of mining fourteen miles of the bed of that portion of the North Fork of the Feather River known as Big Bend. A careful survey had suggested the construction of a tunnel through Big Bend Mountain 12,000 feet long as the most feasible method of draining the channel. Owing to its precipitous banks, but few attempts (and these on a very small scale) had been made to mine this portion of the river. Both above and below Big Bend, however, mining operations had been carried on for many years wherever the water of the river could be turned from its bed by means of hastily-constructed wing dams and ditches or flumes. Only a portion of the summer season could be employed in actual mining, since much time was necessarily con-



PLAN SHOWING TUNNEL AND BIG BEND OF NORTH FORK OF FEATHER RIVER.

sumed in the construction of the diverting works, which were invariably destroyed by high water in the fall. Yet in spite of these drawbacks, many of the Feather River mining ventures had yielded handsome returns. It is chronicled that in 1857, on the old Cape Claim below Big Bend, the sum of $680,000 in gold was taken from 3,300 feet of the channel during the forty working days that intervened between the date of completing the diverting works and the appearance of high water. The expense of draining the channel and working the gravel amounted to $120,000. It was confidently assumed by the projectors of the Big Bend tunnel that the river-bed at Big Bend was equally rich in gold, and that the construction of a permanent channel sufficiently large to take care of the river flow for six months of the year would enable the company to mine more systematically, and therefore more profitably, than was possible with temporary diverting works, which could be utilized for only a brief portion of the season during which they were constructed.

Active work on the tunnel began in November, 1882, after the completion of the necessary roads, trails and buildings, and the installation of an air compressor plant for operating machine drills. The material encountered proved to be slate, of such a character as to require no timbering; and, although hard and firm, it was excavated without difficulty. Excellent progress was made from the beginning, and the spring of 1886 witnessed the completion of the enterprise as originally planned. The cross-section was 9 feet by 16 feet throughout, except at the entrance, where it was enlarged to 9 feet by 32 feet. The grade was 30 feet per mile. Massive iron gates had been constructed for placing at the entrance of the tunnel, and a substantial diverting dam, 125 feet long and 16 feet high, had been completed simultaneously with the prosecution of the work in the tunnel. At this juncture the enterprise received a serious setback. When it was attempted to drain the channel, the startling discovery was made that the tunnel was much too small to carry the entire volume of water flowing in the river. After computing from accurate measurements the amount of surplus water, it was decided to increase the height of the tunnel from 9 feet, as originally designed, to 16 feet. Plans were made for pushing the work vigorously, with as many men as it was possible to work in three eight-hour shifts. By means of suitable cars drawn by a locomotive, the material was promptly removed as fast as excavated. The work continued without cessation until its completion in the fall of 1887—too late for mining that season.

It was now planned to develop sufficient water power at the lower end of the tunnel to operate the machinery required for excavating the gravel, viz., derricks for removing large bowlders and elevating the gravel to sluice boxes, and pumps for disposing of the seepage. A waterwheel and an electric generator were accordingly installed, and a transmission line was constructed around Big Bend. Fifteen years ago electric power transmission was in its infancy. As the Big Bend line was, therefore, largely experimental, it is not surprising that the results proved far from satisfactory. It may be mentioned as a matter of interest that this was chiefly due to the omission from the plant of an accessory which, in these days of successful power development and transmission, is considered a prime essential, i. e., a waterwheel governor.

The power plant, however, proved to be the least of the company's troubles. When mining was at last begun in the summer of 1888, it was found that the cost of excavating was much greater than had been estimated. This was due to the prevalence of large bowlders that could be handled only with the greatest difficulty. In addition to this obstacle, the bedrock, which had been relied upon to yield the largest values, was either inaccessible on account of the extreme depth of the gravel, or was too hard and smooth where the gravel was shallow to have accumulated gold.

Although the season's operations demonstrated the impossibility of profitably mining the Big Bend channel, the company were reluctant to accept the fact. Operations were resumed during the season of 1889; but the second attempt proving no more successful than the first, it was decided before the close of the season to abandon the enterprise. It is said that more than one million dollars were expended by the company during the eight years that elapsed between the inauguration of the project and its unfortunate termination.

And now comes the sequel. During the past five years the successful transmission of power, generated by water, from distant mountain streams to the towns of the Pacific coast has suggested industrial possibilities that were not even dreamed of fifteen years ago. The amazing success, not merely mechanically but commercially as well, of the Standard Electric and Bay Counties Power Companies in transmitting electric power from the Sierra Mountains to the cities on San Francisco Bay, 200 miles distant, has directed the attention of promoters and investors to all the available sources of water power on the western slope of the Sierras. One of the most promising is that secured by the Feather River Power Company, which has recently come into possession of the Big Bend tunnel property. At the end of the tunnel the water has a drop of 350 feet. It is estimated that this will develop no less than 2,500 horse power, making due allowance for loss in transmission to San Francisco, a distance of approximately 200 miles. The one feature of the Feather River power scheme that will appeal to both the engineer and the investor is the permanent character of the hydraulic portion of the plant. Fully to appreciate the value of this feature, it is only necessary to consider the enormous expense of maintaining the many miles of flume and canal construction that characterize certain large power plants in this State. The estimated cost of the entire plant, including the purchase price of the Big Bend Tunnel and Mining Company's property, is approximately $125 per delivered horse power.

When Big Bend tunnel was abandoned thirteen years ago, probably no one considered the possibility of turning the waste water power to profitable account, much less transmitting this power to the Pacific coast. At that time, as we have seen, the transmission of less than 100 horse power a few miles, and its application to the simplest operations, was attended with greater difficulties than the transmission to-day of many thousand horse power to distant points for distribution.

And so it has come to pass that the remarkable development of electrical science during the past few years has paved the way for transforming a disastrous mining failure into a brilliant commercial success.